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MULTI-SHANK RIPPER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Application No. 60/442,031 filed January 23, 2003, which is hereby incorporated by reference.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] This invention has been created without the sponsorship or funding of any federally sponsored research or development program.

BACKGROUND OF THE INVENTION

[0003] This invention is an excavation tool and an excavator system that uses the tool in conjunction with a conventional excavator of the type in which a vehicle is provided with a device commonly known as a "backhoe". The backhoe includes a dipperstick and the tool is mounted on the outboard end of the dipperstick. The tool and system are intended for excavation of difficult to excavate substrate between loose soil or loose gravel and solid rock. This intermediate substrate requires a special tool to be excavated efficiently. Loose soil or gravel can be excavated with a conventional bucket, but the bucket is generally not effective on intermediate substrate. Solid rock excavation generally requires a hydraulic hammer, but the hydraulic hammer is not efficient for excavating intermediate substrate. Attempts have been made to develop tools that are effective and efficient in excavating intermediate substrate. Simply stated, there have been three general approaches. The single tooth approach replaces the bucket or replaces the hydraulic hammer with a tooth on the end of the dipperstick. This has proven to be very inefficient in excavating intermediate substrate. The added articulated tooth approach positions a tooth behind the bucket. This is very awkward and inefficient for excavating intermediate substrate. The multi-tooth bucket approach mounts several teeth on the back side

of the bucket. This approach can be awkward and inefficient for intermediate substrate, and can interfere with the normal operation of the bucket in excavating loose substrate.

[0004] These and other difficulties experienced with the prior art devices have been obviated in a novel manner by the present invention.

[0005] It is, therefore, an outstanding object of the present invention to provide an excavation tool and system that efficiently and effectively excavates intermediate substrate.

[0006] Another object of this invention is to provide an excavation tool and system that provides the operator with maximum visibility of the work area in order to allow precise excavation, especially around obstacles and utilities.

[0007] A further object of the present invention is to provide an excavation tool and system that provide maximum working force to the working tooth in order to efficiently and effectively excavate intermediate substrate.

[0008] It is another object of the invention is to provide an excavation tool and system that provides smooth and minimum stress on the excavating vehicle as it efficiently and effectively excavates intermediate substrate.

[0009] It is a further object of the invention to provide an excavation tool and system which is capable of being manufactured of high quality and at a low cost, and which is capable of providing a long and useful life with a minimum of maintenance.

[0010] With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto, it being understood that changes in the precise embodiment of the invention herein disclosed may be made within the scope of what is claimed without departing from the spirit of the invention.

BRIEF SUMMARY OF THE INVENTION

[0011] This invention is an excavating tool for pivotal attachment about an axis to the outboard end of the dipperstick of an excavating system, the tool having multiple shanks offset

longitudinally of the axis and offset radially about the axis. The tool does not have a bucket configuration. The open structure provides maximum visibility of the work area to the operator. The shanks are arranged on the axis so the, as the tool is rotated about the axis, the shanks engage the substrate serially and axially offset. The plate-like shanks allow debris to be swept sideways out of the work area.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The character of the invention, however, may best be understood by reference to one of its structural forms, as illustrated by the accompanying drawings, in which:

[0013] Figure 1 is a prospective view of a hydraulic excavator which is fitted with a multi-shank excavation tool embodying the principles of the present invention,

[0014] Figure 2 is a rear and right side prospective view of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 1,

[0015] Figure 3 is a front and left side prospective view of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 1,

[0016] Figure 4 is a left elevation view of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 1,

[0017] Figure 5 is a front elevation view of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 1,

[0018] Figure 6 is a front and left side prospective view of a second version of a multi-shank excavation tool embodying the principles of the present invention,

[0019] Figure 7 is a rear elevation view of a second version of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 6,

[0020] Figure 8 is a right elevation view of a second version of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 6,

DETAILED DESCRIPTION OF THE INVENTION

[0021] Referring first to Figure 1 in which the general principles of the present invention are shown, Figure 1 is a prospective view of a hydraulic excavator 10 which is fitted with a multi-shank excavation tool 11 embodying the principles of the present invention and is engaging substrate 14. The excavation tool 11 is pivotally connected to the outboard end of the dipper stick 13 of the hydraulic excavator 10 by means of a quick-change mechanism 12.

[0022] More specifically, the hydraulic excavator 10 includes a chassis 15, tracks 16 and 17 for mobility, and a cab 18 for the operator. Extending from the chassis 15 of the hydraulic excavator 10 is an arm 19. Pivotally attached to the outboard end of the arm 19 is a boom 21. A hydraulic actuator 22 articulates the dipperstick 13. Pivotally attached to the outboard end of the boom 21 is the dipperstick 13. The tool 11 is pivotally attached to the outboard end of the dipperstick 13 by hinge pin 23. Hydraulic actuator 24 articulates the tool 11 about the axis of hinge pin 23.

[0023] The tool 11 includes a connective structure 25 which is connected to the lower side of the quick-change mechanism 12, and, thereby, is connected to the dipperstick 13 and the hydraulic actuator 24. Connected to and descending from the connective structure 25 are three rippers 26, 27, and 28. Each ripper 26, 27, and 28, includes a shank, 31, 32, and 33, respectively, attached at one end to the connective structure 25. Each ripper 26, 27, and 28, includes a ripping tooth 24, 25, and 26 attached to the outboard end of the shank 31, 32, and 33, respectively.

[0024] Figure 2 is a rear and right side prospective view of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 1.

The excavation tool 11 is pivotally connected to the outboard end of the dipper stick 13 (not shown) of the hydraulic excavator 10 (not shown) by means of a quick-change mechanism 12.

[0025] The tool 11 includes a connective structure 25 which is connected to the lower side of the quick-change mechanism 12, and, thereby, is connected to the dipperstick 13 (not shown) and the hydraulic actuator 24 (not shown). Connected to and descending from the connective

structure 25 are three rippers 26, 27, and 28. Each ripper 26, 27, and 28, includes a shank, 31, 32, and 33, respectively, attached at one end to the connective structure 25. Each ripper 26, 27, and 28, includes a ripping tooth 24, 25, and 26 attached to the outboard end of the shank 31, 32, and 33, respectively.

[0026] In this version of the tool 11, the central ripper 27 is connected to a tube 37 which is part of the connective structure 25. The tube is in turn connected between the inside surfaces off the shank 31 in the shank 33.

[0027] Figure 3 is a front and left side prospective view of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 1. The excavation tool 11 is pivotally connected to the outboard end of the dipper stick 13 (not shown) of the hydraulic excavator 10 (not shown) by means of a quick-change mechanism 12.

[0028] The tool 11 includes a connective structure 25 which is connected to the lower side of the quick-change mechanism 12, and, thereby, is connected to the dipperstick 13 (not shown) and the hydraulic actuator 24 (not shown). Connected to and descending from the connective structure 25 are three rippers 26, 27, and 28. Each ripper 26, 27, and 28, includes a shank, 31, 32, and 33, respectively, attached at one end to the connective structure 25. Each ripper 26, 27, and 28, includes a ripping tooth 24, 25, and 26 attached to the outboard end of the shank 31, 32, and 33, respectively.

[0029] In this version of the tool 11, the central ripper 27 is connected to a tube 37 which is part of the connective structure 25. The tube is in turn connected between the inside surfaces off the shank 31 in the shank 33.

[0030] Figure 4 is a left elevation view of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 1. The excavation tool 11 is pivotally connected to the outboard end of the dipper stick 13 (not shown) of the hydraulic excavator 10 (not shown) by means of a quick-change mechanism 12.

[0031] The tool 11 includes a connective structure 25 which is connected to the lower side of the quick-change mechanism 12, and, thereby, is connected to the dipperstick 13 (not shown)

and the hydraulic actuator 24 (not shown). Connected to and descending from the connective structure 25 are three rippers 26, 27, and 28. Each ripper 26, 27, and 28, includes a shank, 31, 32, and 33, respectively, attached at one end to the connective structure 25. Each ripper 26, 27, and 28, includes a ripping tooth 34, 35, and 36 attached to the outboard end of the shank 31, 32, and 33, respectively.

[0032] One of the important physical relationships which exist in the tool 11 is the position of the ends off the ripping teeth 34, 35, and 36 with respect to one another and with respect to the axis of the pivoting motion of the tool 11 with respect to the dipperstick 13, which is represented in Figure 4 by the bore 38 and its axis.

[0033] With regard to the position of the teeth with respect to one another, the teeth are axially offset about the axis of the bore 38, with each tooth offset approximately 15 to 30 degrees (preferably about 20) from each other so that the total from tooth 34 to tooth 36 is approximately 32 to 60 degrees (preferably about 40).

[0034] The ends of the teeth 34, 35, and 36 define a surface of revolution about a surface axis parallel to the axis of the bore 38. Typically, the surface axis would be the axis of the bore 38. However, by shifting the surface axis, particularly by shifting it upward and forward, the manner in which each tooth sequentially contacts and breaks through the surface of the substrate 14 can be optimized for a particular substrate.

[0035] Although, in the preferred embodiment of this invention, right tooth 34 is forward, central tooth 35 is in the middle and left tooth 36 is a rearward, to any other arrangements could be employed as long as the forward, central, and rearward positions are employed.

[0036] Figure 5 is a front elevation view of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 1. The excavation tool 11 is pivotally connected to the outboard end of the dipper stick 13 (not shown) of the hydraulic excavator 10 (not shown) by means of a quick-change mechanism 12.

[0037] The tool 11 includes a connective structure 25 which is connected to the lower side of the quick-change mechanism 12, and, thereby, is connected to the dipperstick 13 (not shown)

and the hydraulic actuator 24 (not shown). Connected to and descending from the connective structure 25 are three rippers 26, 27, and 28. Each ripper 26, 27, and 28, includes a shank, 31, 32, and 33, respectively, attached at one end to the connective structure 25. Each ripper 26, 27, and 28, includes a ripping tooth 24, 25, and 26 attached to the outboard end of the shank 31, 32, and 33, respectively.

[0038] One of the important physical relationships which exist in the tool 11 is the lateral position of the ends of the ripping teeth 34, 35, and 36 with respect to one another and with respect to the centerline of the tool 11, that is, one of the teeth is on the centerline of the tool 11, one of the teeth is on the right, and the teeth is on the left.

[0039] Figure 6 is a front and left side prospective view of a second version of a multi-shank excavation tool embodying the principles of the present invention. The excavation tool 11a is pivotally connected to the outboard end of the dipper stick 13 (not shown) of the hydraulic excavator 10 (not shown) by means of a conventional connecting mechanism 41.

[0040] The tool 11 includes a connective structure 25a which is connected to the lower side of the conventional connecting mechanism 41, and, thereby, is connected to the dipperstick 13 (not shown) and the hydraulic actuator 24 (not shown). Connected to and descending from the connective structure 25a are three rippers 26a, 27a, and 28a. Each ripper 26a, 27a, and 28a, includes a shank 31a, 32a, and 33a, respectively, attached at one end to the connective structure 25a. Each ripper 26a, 27a, and 28a, includes a ripping tooth 24a, 25a, and 26a attached to the outboard end of the shank 31a, 32a, and 33a, respectively.

[0041] In this version of the tool 11a, the central ripper 27a is connected directly to the connective structure 25.

[0042] Figure 7 is a rear elevation view of a second version of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 6. The excavation tool 11a is pivotally connected to the outboard end of the dipper stick 13 (not shown) of the hydraulic excavator 10 (not shown) by means of a conventional connecting mechanism 41.

[0043] The tool 11a includes a connective structure 25a which is connected to the lower side of the conventional connecting mechanism 41, and, thereby, is connected to the dipperstick 13 (not shown) and the hydraulic actuator 24 (not shown). Connected to and descending from the connective structure 25a are three rippers 26a, 27a, and 28a. Each ripper 26a, 27a, and 28a, includes a shank 31a, 32a, and 33a, respectively, attached at one end to the connective structure 25a. Each ripper 26a, 27a, and 28a, includes a ripping tooth 24a, 25a, and 26a attached to the outboard end of the shank 31a, 32a, and 33a, respectively.

[0044] One of the important physical relationships which exist in the tool 11 is the lateral position of the ends of the ripping teeth 34a, 35a, and 36a with respect to one another and with respect to the centerline of the tool 11, that is, one of the teeth is on the centerline of the tool 11a, one of the teeth is on the right, and the teeth is on the left.

[0045] Figure 8 is a right elevation view of a second version of a multi-shank excavation tool embodying the principles of the present invention and shown in Figure 6. The excavation tool 11a is pivotally connected to the outboard end of the dipper stick 13 (not shown) of the hydraulic excavator 10 (not shown) by means of a conventional connecting mechanism 41.

[0046] The tool 11a includes a connective structure 25a which is connected to the lower side of the conventional connecting mechanism 41, and, thereby, is connected to the dipperstick 13 (not shown) and the hydraulic actuator 24 (not shown). Connected to and descending from the connective structure 25a are three rippers 26a, 27a, and 28a. Each ripper 26a, 27a, and 28a, includes a shank 31a, 32a, and 33a, respectively, attached at one end to the connective structure 25a. Each ripper 26a, 27a, and 28a, includes a ripping tooth 34a, 35a, and 36a attached to the outboard end of the shank 31a, 32a, and 33a, respectively.

[0047] One of the important physical relationships which exist in the tool 11 is the position of the ends off the ripping teeth 34a, 35a, and 36a with respect to one another and with respect to the axis of the pivoting motion of the tool 11 with respect to the dipperstick 13, which is represented in Figure 8 by the forward bore in the connecting mechanism 41 and the bore's axis.

[0048] With regard to the position of the teeth with respect to one another, the teeth are axially offset about the axis of the bore, with each tooth offset approximately 15 to 30 degrees (preferably about 20) from each other so that the total from tooth 34a to tooth 36a is approximately 32 to 60 degrees (preferably about 40).

[0049] The ends of the teeth 34a, 35a, and 36a define a surface of revolution about a surface axis parallel to the axis of the bore. Typically, the surface axis would be the axis of the bore. However, by shifting the surface axis, particularly by shifting it upward and forward, the manner in which each tooth sequentially contacts and breaks through the surface of the substrate 14 can be optimized for a particular substrate.

[0050] Although, in the preferred embodiment of this invention, right tooth 34a is forward, central tooth 35a is in the middle and left tooth 36a is a rearward, to any other arrangements could be employed as long as the forward, central, and rearward positions are employed.

[0051] OPERATION OF THE TOOL:

[0052] The operation of the tool 11 which is subject of this invention is typically carried out as follows. In the case of a generally horizontal substrate 14, the tool 11 is pivoted all the way back on the end of the dipperstick 13 and extended as far forward of the chassis 15 is possible. The tool 11 is lowered until the leading tooth, typically tooth 34, engages the substrate 14. Then the tool is pulled downward and toward the chassis 15 so that the tooth 34 penetrates the surface of the substrate 14 and begins ripping the substrate. Simultaneously, the tool 11 is pivoted forward so that as each tooth breaks through the surface of the substrate 14, the tooth rearward of it contacts and begins breaking through the surface of the substrate 14.

[0053] The Multi-Shank Ripper:

[0054] The multi-shank ripper is a new design of a tool that is to be used by backhoes and excavators for the purpose of ripping hard materials. The tool can be used for a wide range of

tough material applications such as ripping frozen ground, coral, sandstone, limestone, shale and caliche, and even ripping stumps.

[0055] The bucket cylinder force produces the highest breakout forces on a backhoe or excavator. With the stick in the near vertical position, the operator uses a combination of bucket and crowd cylinder functions while providing boom cylinder down pressure. The tool is then rolled completely so that all teeth have engaged the material. The rolling of the tool process, by extending the bucket cylinder, always provides the full breakout force so that the substrate is ripped out by the lifting action of each tooth. The ripper teeth fracture the substrate in sequential order. No two ripper teeth align with each other, so the maximum breakout force is applied sequentially to each tooth. The castle top shape groves cut by the front ripper teeth facilitates the fracturing process of the rear teeth. The result is a relatively flat trench bottom cut, due to the fact that the ripper tooth tips all lie on a constant radius with a center of rotation that is close to the tractor loader backhoe or hydraulic excavator "dipper stick" bucket pivot. This unique design has demonstrated that it can dig several times faster than using a single pointed ripper tooth. The last tooth can also be used as a pick. The Multi-Ripper functions far superior to a conventional single pointed ripper because of the shortened tip radius and the "catching effect" on the machine. When using a single pointed ripper, the tooth would hang up on a spot, and then break loose. When this would happen, the machine would drop. When using the Multi-Ripper, when the spot would break free, the next tooth would be there to catch the machine. The force of the machine dropping on that tooth would cause a picking effect and break that part off and the machine would drop again and be caught by the next tooth.

[0056] The design is similar to that of a "Ripper Bucket® " patent numbers: 4,279,085 and 4,457,085 except while these designs reflect a bucket with ripper teeth along the back, the Multi-Ripper design is a ripper only. No other product is similar in function except the Ripper Bucket. (Ripper Bucket® is a registered trademark of Woods Equipment Company)

[0057] The advantages of this Multi-Ripper over the Ripper Bucket design are related to the visibility, the power, the depth of cut, and the cost. The visibility is much better because the

operator can see through the tines of the ripper to see what he is doing. With the Ripper Bucket, the operator cannot see through the bucket so they are ripping "blind."

[0058] The power, or forces generated, of the Multi-Ripper are substantially higher due to the considerable shorter tip radius. Because there is no bucket function, the shank length is shortened. This shorter length decreases the moment arm and thus increases the tip forces. These forces are so high that the teeth are able to rip out rocks imbedded in caliche. The forces are approximately 40% higher than a comparable Ripper Bucket. Many operations would required the use of a hydraulic hammer prior to this new tool.

[0059] The depth of the cut is deeper than the Ripper Bucket. After pieces are broken from the substrate, they would build up under the Ripper Bucket and the bucket would float on these pieces thus not allowing the teeth to engage the deeper unripped material. On the Multi-Ripper tool, since there is not bucket, the pieces of the material flow through the tines thus allowing the shanks to engage the unripped material below the thick debris layer.

[0060] The cost of the tool is considerably less than the Ripper Bucket because there is no bucket structure. The combined price of the Multi-Ripper tool plus a heavy duty bucket is still less than a Ripper Bucket. The Riper Bucket is expensive because the structure has to support the ripping function while functioning as a bucket.

[0061] This tool is new to the industry and increases the versatility of the backhoe or small hydraulic excavator! The new Multi-Ripper Tool will quickly attach to any similar style Quick Change coupler and is very handy for tough ripping applications. The Multi-Ripper Tool is inexpensive and is useful for any application where one would use a single pointed ripper except three times as fast! The operation is similar to the DigNRip™ Bucket except it provides the ripper function only, and is less expensive.

[0062] Specifications:

Weight = 280 pounds

Three series 23 twin tiger teeth

Short tip radius for higher breakout forces!

[0063] Description of the preferred embodiment:

[0064] The preferred embodiment shows the Multi-Ripper Tool connected to a quick change coupler. Although this is not required, it allows for quick changes to a bucket for material removal. A direct pin version would be similar except there would be no separation between the backhoe or excavator linkage pin ears and the tool itself. The side plates would then extend up and pick up the linkage pin bosses without a coupler.

[0065] The tool is made up of three removable ripper teeth that are positioned so that the tips lie on an arc that has its arc center very close to the dipper pivot. There could be any number of teeth as long as there are three or more. From side to side, the teeth do not lie in the same plane. In the preferred embodiment, the first engaging tooth is on the right side of the tool, the second tooth is in the middle, and the third tooth is on the left. These teeth can be positioned differently as long as they lie on the arc (as viewed from the side) and they are not in the same plane. For example, the center tooth could be the first engaging tooth and then the right and then the left. The structure is such that the center tooth shank is mounted to a cross tube. This is not required, however, for the structure, the cross tube adds a considerable amount of torsional rigidity. For a pin-on version for example, the two side plates could pick up the linkage mounting collars and they could be separated by a cross tube that is connected to the center shank. This center shank could be the last engaging tooth, as opposed to the second engaging tooth.

[0066] The teeth are connected to a nose piece adapter that is easily weldable to a shank. This nose piece could be exchanged for a conventional tooth adapter as long as the shank was cut to form around the adapter.

[0067] The tooth angle is such that each tooth is angled approximately the same from the tangent to the earlier mentioned arc that passes near the dipper pivot. This optimum angle depends on the tooth manufacture but it is somewhere between 30 and 45 degrees away from the tangent to this arc.

[0068] The teeth could be any style teeth used for penetration, such as tiger points or twin tigers. Other tooth designs can be used for other applications, such as stump removal.
[0069] The shanks are designed to withstand the high breakout forces. The shanks are thick plates in the preferred embodiment; however, these could be hollow structures as long as they withstand the high breakout forces.

[0070] The "3-Stage, Multi-Ripper":
[0071] What is a Multi-Ripper? A MULTI_RIPPER is an excavation tool designed to handle the more severe frost and rock removal jobs. The Leading Edge Attachments, Inc.'s Multi-Ripper™ is an engineering breakthrough! The Multi-Ripper can be used for a wide range of tough material applications such as excavating frozen ground, coral, sandstone, limestone, shale, decomposed granite and caliche. This unique design has demonstrated that it can dig 10 times faster than using a single pointed ripper tooth, and 4 times faster than a hydraulic hammer! Under severe digging conditions, the performance also exceeds other designs of frost, rock or Buckets. This design is also a mining industry breakthrough for the purpose of wall and roof rock scaling! The new Multi-Ripper is available to fit any excavator or backhoe above 11,000 pounds.
[0072] How Leading Edge Attachment, Inc.'s Multi-Ripper Works. The Multi-Ripper functions similarly to that of a trencher except it uses the hydraulic excavator rolling action to rip. The bucket cylinder force produces the highest breakout forces on a backhoe or excavator. With the stick in the near vertical position, the operator uses a combination of bucket and crowd cylinder functions while providing boom cylinder down pressure. The tool is then rolled completely so that all teeth have engaged the material. The rolling of the tool process, by extending the bucket cylinder, always provides the full breakout force so that the substrate is ripped out by the lifting action of each tooth. The ripper teeth fracture the substrate in sequential order. No two ripper teeth align with each other, so the maximum breakout force is applied sequentially to each tooth. The castle top shape groves cut by the

front ripper teeth facilitates the fracturing process of the rear teeth. The result is a relatively flat trench bottom cut, due to the fact that the ripper tooth tips all lie on a constant radius with a center of rotation that is close to the tractor loader backhoe or hydraulic excavator "dipper stick" bucket pivot. The Multi-Ripper functions in a far superior manner to a conventional single pointed ripper because of the shortened tip radius and the "catching effect" on the machine. When using a single pointed ripper, the tooth would hang up on a spot, and then break loose. When this would happen, the machine would drop. When using the Multi-Ripper, when the spot would break free, the next tooth would be there to catch the machine. The force of the machine dropping on that tooth would cause a picking effect and break that part off and the machine would drop again and be caught by the next tooth.

[0073] The design is analogous to that of a "Ripper Bucket®" patent numbers: 4,279,085 and 4,457,085 except while these designs reflect a bucket with ripper teeth along the back, the Multi-Ripper design is a ripper only. No other product is similar in function except the Ripper Bucket. (Ripper Bucket® is a registered trademark of Woods Equipment Company)

[0074] The advantages of this Multi-Ripper over the Ripper Bucket design are related to the visibility, the power, the depth of cut, and the cost. The visibility is much better because the operator can see through the tines of the ripper to see what he is doing. With the Ripper Bucket, the operator cannot see through the bucket, because the bottom of the bucket is in the way, so the operator is ripping "blind".

[0075] The power, or forces generated, of the Multi-Ripper are substantially higher due to the considerable shorter tip radius. Because there is no bucket function, the shank length can be shortened. This shorter length decreases the moment arm and thus increases the tip forces. These forces are so high that the teeth are able to rip out rocks imbedded in caliche. The forces are approximately 40% higher than a comparable Ripper Bucket. Many operations would require the use of a hydraulic hammer prior to this new tool.

[0076] The power is also applied to the substrate more consistently with the Multi-Ripper, than occurs with the Ripper Bucket. The Ripper bucket corner teeth contact the substrate at

the same time, so the load is shared between these two teeth. So, when viewed from the side, the Ripper bucket does indeed have two teeth that are aligned, the corner teeth! With the Multi-Ripper, there are not two teeth that align either longitudinally or transversely. This allows all of the power to be transmitted through one tooth at a time.

[0077] The depth of the cut of the Multi-Ripper is deeper than that of the Ripper Bucket. After pieces are broken from the substrate, they would build up under the Ripper Bucket and the bucket would float on these pieces thus not allowing the teeth to engage the deeper unripped material. On the Multi-Ripper tool, since there is no bucket, the pieces of the material flow between the tines thus allowing the shanks to engage the unripped material below the thick debris layer. The multiple shanks also push the loosened material out of the way to expose un-ripped material. The Multi-Ripper will function, and greatly exceed, any application, or material, that a single pointed ripper tooth can be used for.

[0078] The cost of the tool is considerably less than the Ripper Bucket because there is no bucket structure. The combined price of the Multi-Ripper tool plus a heavy duty bucket is still less than a Ripper Bucket. The Riper Bucket is expensive because the structure has to support the ripping function while functioning as a bucket.

[0079] Multi-Ripper Operating Procedure: With the stick in the near vertical position, use a combination of bucket and crowd cylinder functions while providing boom cylinder down pressure. The bucket cylinder action provides the greatest force while the stick sweeps. Since no two teeth are in alignment, when the Multi-Ripper is rolled, each tooth engages separately so that each tooth fractures the groove cut by the preceding tooth. Roll the Multi-Ripper completely as the stick is being moved so that all teeth have engaged the material. The Multi-Ripper is to be rolled as the stick is moved, thus causing a very powerful, fast and effective ripping motion that is easy on the machine and operator.

[0080] What makes this product different from its competitors? The MultiRipper™ is different from anything on the market. There is no excavator ripper that has multiple shanks staggered and on an arc so that each tooth hits individually. The Multi-Ripper will

the same time, so the load is shared between these two teeth. So, when viewed from the side, the Ripper bucket does indeed have two teeth that are aligned, the corner teeth! With the Multi-Ripper, there are not two teeth that align either longitudinally or transversely. This allows all of the power to be transmitted through one tooth at a time.

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[0078] The cost of the tool is considerably less than the Ripper Bucket because there is no bucket structure. The combined price of the Multi-Ripper tool plus a heavy duty bucket is still less than a Ripper Bucket. The Riper Bucket is expensive because the structure has to support the ripping function while functioning as a bucket.

[0079] Multi-Ripper Operating Procedure: With the stick in the near vertical position, use a combination of bucket and crowd cylinder functions while providing boom cylinder down pressure. The bucket cylinder action provides the greatest force while the stick sweeps. Since no two teeth are in alignment, when the Multi-Ripper is rolled, each tooth engages separately so that each tooth fractures the groove cut by the preceding tooth. Roll the Multi-Ripper completely as the stick is being moved so that all teeth have engaged the material. The Multi-Ripper is to be rolled as the stick is moved, thus causing a very powerful, fast and effective ripping motion that is easy on the machine and operator.

[0080] What makes this product different from its competitors? The MultiRipper™ is different from anything on the market. There is no excavator ripper that has multiple shanks staggered and on an arc so that each tooth hits individually. The Multi-Ripper will

outperform or replace the closest products on the market in function, namely, the hydraulic hammer, ripping buckets or designs similar to the LEA DigNRip™ Bucket, or the single pointed ripper.

[0081] The Multi-Ripper can replace all hydraulic hammer applications where there is fragmented rock or frozen ground! For these tough applications, the Multi-Ripper is superior to a hydraulic hammer for the following reasons:

[0082] The Multi-Ripper is 4 times faster than a hydraulic hammer. Because the hydraulic hammer has one speed (tink-tink-tink), the amount of material breaking is at one rate. With the Multi-Ripper, after one tooth breaks out some material, the second tooth is there ready to strike, and then the third. With the combination of the rolling of the bucket cylinder and the raking of the stick cylinder, the operation becomes very fast. Many operators have testified that for use in fragmented rock like caliche, limestone, shale, decomposed granite and similar materials, that the Multi-Ripper outperforms the hydraulic hammer 4 to 1!

[0083] The operator does not have to clean up until the material is broken out. With a hydraulic hammer, as the material is broken out it sits there on top of the work area. As the loosened material accumulates, a machine with a bucket has to come in to clean up. With the Multi-Ripper, the shanks flip the loosened material out of the way until the whole trench ripping operation is complete. The area can then be rapidly cleaned up afterward with a conventional bucket, so you only have to switch attachments once!

[0084] The Multi-Ripper is cheaper to operate than a hydraulic hammer. A hydraulic hammer requires maintenance. There are multiple hydraulic components, there are hydraulic fittings and hoses, and the tools, or "moil" has to be replaced, there is "down time" with a hydraulic hammer. With the Multi-Ripper there are no moving parts and the teeth are the only wear items. These teeth are usually set up so that they are the same tooth connection as what exists on the excavator bucket itself, so they are readily available.

[0085] The Multi-Ripper is one tenth the price of a hydraulic hammer. A hammer for an 80,000 pound size class machine could run between $75,000 and $100,000. The Multi-Ripper

price for that machine is only $7,656. The operator can set their machine up with a hydraulic kit for a hydraulic hammer. When those infrequent situations occur when the material is a solid mass that is not fragmented, the operator can rent a hydraulic hammer for that solid portion only. Since the Multi-Ripper will handle the majority of the ledge and fractured rock applications, the hydraulic hammer will be rarely required.

[0086] The operator will make more money with the Multi-Ripper than the hydraulic hammer. If one compares the price of the hammer, the maintenance, the down time and the functionality into account, it is easy to see that the Multi-Ripper will net the contractor more income. Even though the operator can charge an additional amount for the use of the hydraulic hammer over the use of a bucket, the operator can still charge more for the use of a Multi-Ripper than for the use of the bucket. Since the Multi-Ripper contractor can work faster than the hydraulic hammer contractor, the Multi-Ripper contractor will be assured more jobs because it will ultimately cost less for the hiring builder.

[0087] The Multi-Ripper is superior to the DigNRip Bucket (or the Ripper Bucket) for ripping for several reasons:

[0088] The Multi-Ripper has a shorter length. Since the DigNRip Bucket has to have its pin-to-point (tip radius) similar to a bucket (because the teeth are mounted on the outside of the bucket) this distance is fairly long. The Multi-Ripper can be much shorter in length which increases the forces on the tips of the teeth. The Multi-Ripper has a force multiplying effect compared to a bucket.

[0089] The Multi-Ripper always has only one tooth engaging at a time. While the DigNRip Bucket has several teeth along the front leading edge that will engage at the same time, the Multi-Ripper never has more than one tooth engaging at one time. This allows the full bucket cylinder force to be exerted on the single tooth. The teeth on the back of the DigNRip Bucket eventually hit one at a time. However, that is only after the front lip has cleared the material.

[0090] The Multi-Ripper visibility is better. With a DigNRip Bucket the operator cannot see through the bucket so the operator is working blind. With the Multi-Ripper, the operator can see between the shanks to see what the shanks are doing. This works well when ripping around utilities.

[0091] The operator can rip longer with the Multi-Ripper. Because of the multiple shanks, the operator can flip the broken out material out of the way to expose virgin rock. If you compare this to a single pointed ripper or a hammer, the operator would have to switch to a bucket to remove the loosened material. Even with the DigNRip Bucket, one can only rip so far and then they have to scoop the material out because of the limitation of the back of the bucket. With the Multi-Ripper, one can rip the whole trench all the way to the desired level by pushing the loosened material away. Then the operator can come back with a standard bucket afterward for quick cleanup.

[0092] The Multi-Ripper costs less. An operator can purchase a Multi-Ripper and a severe duty bucket for less than what a DigNRip Bucket alone would cost.

[0093] The Multi-Ripper is easier on the machine. With the Multi-Ripper, the ripping operation is fairly smooth. As one tooth breaks free, the next tooth is there to pick up the load. With a DigNRip Bucket, the front leading edge hangs up on the material because several teeth become engaged at the same time. Then, when the front leading edge breaks free, the machine lurches forward and drops, then the teeth on the back pick up. Several operators that have used both the Multi-Ripper and the DigNRip Bucket have mentioned this profound effect and smoothness of the Multi-Ripper.

[0094] The Multi-Ripper is 10 times faster than a single pointed ripper!

[0095] The Multi-Ripper is more powerful than a single pointed ripper! Conventional single pointed rippers are as long as a bucket and have only one tooth! The Multi-Ripper is considerably shorter thus causing the force multiplication effect that can be up to twice the normal breakout force of the machine!

[0096] The Multi-Ripper can move the broken material out of the way! Not only are the forces smaller and there are less teeth to rip, but there is no way to flip the material out of the way to expose virgin material. The process of switching back and forth from the ripper to the bucket can be very time consuming. Experience indicates that the Multi-Ripper is at least three times faster than a single pointed ripper because it has three teeth; however, it is actually 10 times faster because of the force multiplication, the multiple teeth, and its ability to move the material out of the way.

[0097] Comments relating to the preferred embodiment:

[0098] The preferred embodiment shows the Multi-Ripper Tool connected to a quick change coupler. Although this is not required, it allows for quick changes to a bucket for material removal. A direct pin version would be similar except there would be no separation between the backhoe or excavator linkage pin ears and the tool itself. The side plates would then extend up and pick up the linkage pin bosses without a coupler.

[0099] The tool is made up of three ripper teeth that are positioned so that the tips lie on an arc that has its arc center close to and above the dipper pivot. The center of this arc is positioned above and forward of the dipperstick pivot so that, in the case of a pin-on version, if the operator chose to use a coupler, the arc would approximately align with the dipperpivot of the coupler which is usually higher and forward of the original dipperpivot. Since the ripping action is usually comprised of a combination of bucket cylinder rolling and the stick raking action, the cutting angles are optimized by keeping this arc center above and forward of the dipper pivot rotation center. There could be any number of teeth as long as there are three or more. From side to side, the teeth do not lie in the same plane. In the preferred embodiment, the first engaging tooth is on the right side of the tool, the second tooth is in the middle, and the third tooth is on the left. These teeth can be positioned differently as long as they lie on the arc (as viewed from the side) and they are not in the same plane. For example, the center tooth could be the first engaging tooth and then the right and then the left. The structure is such that the center tooth shank is mounted to a cross tube. This is not

required, however, for the structure, the cross tube adds a considerable amount of torsional rigidity. For a pin-on version for example, the two side plates could pick up the linkage mounting collars and they could be separated by a cross tube that is connected to the center shank. This center shank could be the last engaging tooth, as opposed to the second engaging tooth.

[0100] The teeth are connected to a nose piece adapter that is easily weldable to a shank. This nose piece could be exchanged for a conventional tooth adapter as long as the shank was cut to form around the adapter. Conventional crawler tractor ripper teeth and shanks can also be used for this application, or the device could be made with no teeth at all.

[0101] The tooth angle is such that each tooth is angled approximately the same from the tangent to the earlier mentioned arc that passes near the dipper pivot. This optimum angle depends on the tooth manufacture but the center line of the tooth as viewed from the side is somewhere between 20 to 50 degrees away from the tangent to this arc. Since the tooth is usually comprised of a top and a bottom cutting surface, the top surface would be between 35 and 70 degrees from the tangent of the arc.

[0102] The teeth could be any style teeth used for penetration, such as tiger points or twin tigers. Other tooth designs can be used for other applications, such as for stump removal.

[0103] The distance from the dipperstick pivot to the tips of the ripper teeth are at least 20% less that the tip radius dimension of a comparable bucket for a given machine. This amplifies the breakout forces.

[0104] The shanks are designed to withstand the high breakout forces. The shanks are thick plates in the preferred embodiment; however, these could be hollow structures as long as they withstand the high breakout forces.

[0105] COMPARISON OF MULTI-RIPPER TO THE RIPPER BUCKET®

[0106] The functions and benefits of the MULTI-RIPPER can be usefully explained by comparing the MULTI-RIPPER to an commercially available competitive product, called the

"RIPPER BUCKET" , covered in U.S. patents numbers: 4,279,085 and 4,457,085. Ripper Bucket® is a registered trademark of Woods Equipment Company. The design of the Multi-Ripper is somewhat analogous to that of a "Ripper Bucket®" except there are some major practical differences which provide important advantages to the MULTI-RIPPER. While the Ripper Bucket design reflects a bucket with ripper teeth along the back outer surface, the Multi-Ripper design is a ripper only, with no bucket bottom and no front leading cutting edge. Now that quick change couplers are more common in the field, with one, it becomes very fast to be able to switch from the Multi-Ripper to a conventional trenching bucket and back to the Multi-Ripper again. The need to have a ripper and a bucket combined is reduced, especially with the use of a quick coupler.

[0107] No current or previous product is similar in function to the Multi-Ripper. However, the Ripper Bucket is the closes alternative.

[0108] There are many advantages of the Multi-Ripper over the Ripper Bucket design. The Ripper bucket design is a compromised bucket design with a compromised ripper system attached. The Multi-Ripper is a superior ripper design.

[0109] The following is a list of differences and advantages of the Multi-Ripper over the Ripper Bucket.

[0110] The multi-Ripper has no curved sheet bucket bottom like the Ripper Bucket

[0111] Tip radius advantage: The power, or forces generated, of the Multi-Ripper are substantially higher due to the considerable shorter tip radius. Because there is no bucket function, the shank length is able to be shortened. This shorter length decreases the moment arm and thus increases the tip forces. These forces are so high that the teeth are able to rip out rocks imbedded in fragmented rock. The forces are approximately 40% higher than a comparable Ripper Bucket. Many operations would require the use of a hydraulic hammer prior to this new tool. The Ripper Bucket design cannot be made with such a short tip radius, so this feature is unique to the Multi-Ripper.

[0112] Ripper shank structural advantage: The center shanks on the Ripper Bucket are attached to the bucket bottom. The high ripper forces are continuously prying on these shanks causing an "oil can" effect on the bucket bottom. Special manufacturing and design techniques must be employed in order to ward off fatigue cracks from appearing on the Ripper Bucket. The Multi-Ripper is very simple in design with the shanks attached to a direct structural tube member, so lower stresses are apparent throughout, thus reducing the chances of fatigue cracks. The Ripper Bucket design cannot be made with directly connected shanks to a cross tube, so this feature is unique to the Multi-Ripper.

[0113] Visibility advantage: The visibility of the Multi-Ripper is much better because the operator can see through the tines of the ripper to see what he is doing. With the Ripper Bucket, the operator cannot see through the bucket bottom so he is ripping "blind." There is no way that one can design a Ripper Bucket so that you can see through the bucket bottom to the ripper tips, so this feature is unique to the Multi-Ripper.

[0114] Manufacturing simplicity advantage: The cost of the tool is considerably less than the Ripper Bucket because there is no bucket structure. The combined price of the Multi-Ripper tool plus a heavy duty bucket is still less than a Ripper Bucket. The Riper Bucket is expensive because the structure has to support the ripping function while functioning as a bucket. The Ripper Bucket design cannot be made in such a simple fashion, so this feature is unique to the Multi-Ripper.

[0115] Material flow resistance advantage: Since the Ripper Bucket has the bottom of the bucket present; the material is being scooped into the bucket and thus causes a resistance to the forward crowd forces that contribute to the ripping forces. The Multi-Ripper forces are concentrated on the ripping function and have very little drag through the ripped material. The Ripper Bucket design cannot be made so that the drag is reduced to the level of the Multi-Ripper, so this feature is unique to the Multi-Ripper.

[0116] Depth of rip advantage: The depth of the cut of the Multi-Ripper is deeper than the Ripper Bucket. After pieces are broken from the substrate, they build up under the Ripper

Bucket bottom and the bucket floats on these pieces thus not allowing the teeth to engage the deeper unripped material. On the Multi-Ripper tool, since there is no bucket bottom, the pieces of the material flow through the tines thus allowing the shanks to engage the unripped material below the thick debris layer. The multiple shanks also push the loosened material out of the way to expose un-ripped material. The Ripper Bucket design cannot be made without a bottom to allow the rippers to penetrate deeper, so this feature is unique to the Multi-Ripper.

[0117] The Multi-Ripper has no bucket leading edge lip like the Ripper Bucket.

[0118] Individual tooth contact advantage: The power is also consistent with the Multi-Ripper as opposed to the Ripper Bucket. The Ripper bucket corner teeth contact the substrate at the same time, so the load is shared between these two teeth. So, when viewed from the side, the Ripper bucket does indeed have two teeth that are aligned transversely, the corner teeth! With the Multi-Ripper, there are not two teeth that align either longitudinally or transversely. This allows all of the power to be transmitted through one tooth at a time. The old Ripper Bucket patents claim this feature; however, the art does not show it as following these criteria. The Ripper Bucket design cannot be made without creating a leading edge with corners, so this feature is unique to the Multi-Ripper.

[0119] Visibility advantage: Again, since the leading edge of the Ripper Bucket crosses transversely in order to form a bucket, the leading edge creates a vision obstruction between the operator and the tooth tips. The Multi-Ripper has unobstructed visibility because there is no need for a front bucket leading edge. The Ripper Bucket design cannot be made with a leading edge that does not obstruct the ripper teeth, so this feature is unique to the Multi-Ripper.

[0120] Material flow resistance advantage: The leading edge itself causes a material flow resistance that subtracts from the ripping forces. Since the Multi-Ripper has no leading edge to drag through the substrate, all of the forces are concentrated on the teeth tips. The Ripper Bucket design cannot be made without a front leading edge, so this feature is unique to the Multi-Ripper.

[0121] Depth of rip advantage: Once again, just like the bucket bottom, the Ripper Bucket front leading edge restricts the depth that the rippers can penetrate the material. Since there is not need for a front leading edge on the Multi-Ripper, the teeth are unrestricted from penetrating much deeper into the material. The Ripper Bucket design cannot be made without a front leading edge that restricts the tooth depth of cut, so this feature is unique to the Multi-Ripper.

[0122] Machine wear and tear advantage: With the Multi-Ripper, the ripping operation is fairly smooth. As one tooth breaks free, the next tooth is there to pick up the load. With a Ripper Bucket, the front leading edge and two corner teeth hang up on the material because the leading edge and the multiple teeth become engaged at the same time. Then, when the front leading edge breaks free, the machine lurches forward and drops, then the teeth on the back engage. Several operators that have used both the Multi-Ripper and the Ripper Bucket have mentioned this profound effect and smoothness of the Multi-Ripper.

[0123] Multi-Ripper is not a bucket like the Ripper Bucket.

[0124] Faster ripping advantage: There are operators who would simply like to rip without scooping the material. The Ripper Bucket forces the operator to collect material in the bucket while ripping. With the Multi-Ripper, the operator can do all of the necessary ripping, and then come back with the appropriate tool to collect the material if they would like. If an operator wanted to simply "till" the soil to expose buried rocks or loosen the ground, the Multi-Ripper would be a superior tool compared to the Ripper Bucket. The Ripper Bucket design cannot be made so that the operator does not scoop with the bucket, so this feature is unique to the Multi-Ripper.

[0125] Tooth tip arc center is either at dipper pivot (like the RB) or higher and forward.

[0126] Machine momentum advantage. With the Multi-Ripper, since there is no ripping drag from the leading edge or the bucket bottom, after the first tooth breaks out material, the machine nose dives, then the second tooth engages and this energy is transferred to the second tooth ripping function. After the second tooth breaks free, the same effect happens

and on to subsequent teeth. Since this machine momentum effect is so powerful, the rear teeth are able to rip more aggressively than the front tooth. For this reason, we have found that by positioning the ripper tip arc center higher and forward of the dipper pivot, this momentum effect is utilized. The Ripper Bucket has some potential to have this same effect, however, the bucket bottom and front leading edge cause the above mentioned depth of cut and drag restrictions.

[0127] It is obvious that minor changes may be made in the form and construction of the invention without departing from the material spirit thereof. It is not, however, desired to confine the invention to the exact form herein shown and described, but it is desired to include all such as properly come within the scope claimed.

[0128] The invention having been thus described, what is claimed as new and desire to secure by Letters Patent is: